Fabrication and Performance Evaluation of Rectangular and Circular Cross Section Solar Water Heaters.

Course Title: Project and Thesis

Course Code: ME-400

SUBMITTED BY

A MAJID MOLLA	ID: BME1903019351
S M SAIMUN ISLAM	ID: BME1903019340
MD. KAMRUL ISLAM	ID: BME1903019263
MD. SAIFUL NAYEM	ID: BME1903019296
MD. MOHIBULLA	ID: BME1903019104

SUPERVISED BY

A M M SHAMSUL ALAM

Associate Professor

Department of Mechanical Engineering

Sonargaon University (SU)

Dhaka-1215, Bangladesh

28 May, 2023

DECLARATION

We do hereby solemnly declare that, the work presented here in this project report has been carried out by us and has not been previously submitted to any University/ Organization for award of any degree or certificate.

………………….	………………..
A Majid Molla	Md.Mohibulla
……………………	…………………….
S.M. Saimun Islam	Md.Saiful Nayem
…………………..	
Md.Kamrul Islam	

Certification

This is to certify that this project entitled "Fabrication and performance evaluation of rectangular and circular cross section solar water heaters" is done by the following students under my direct supervision. This project work has been carried out by them in the laboratories of the Department of Mechanical Engineering under the faculty of Engineering, Sonargaon University (SU) in partial fulfillment of the requirements for the degree of Bachelor of Science in Mechanical Engineering.

SUPERVISOR:

………………

A M M Shamsul Alam
Associate Professor
Department of Mechanical Engineering
Sonargaon University (SU)
Dhaka-1215, Bangladesh

ACKNOWLEDGEMENT

First, we started in the name of almighty Allah. This thesis is accomplished under the supervision of **A M M Shamsul Alam, Associate Professor**, Department of Mechanical, Sonargaon University. It is a great pleasure to acknowledge our profound gratitude and respect to our supervisor for this consistent guidance, encouragement, helpful suggestion, constructive criticism and endless patience through the progress of this work. The successful completion of this thesis would not have been possible without his persistent motivation and continuous guidance.

The authors are also grateful to **Professor Md. Mostofa Hossain**, Head of the Department of Mechanical Engineering and all respect teachers of the Mechanical Engineering Department for their co-operation and significant help for completing the thesis work successfully.

ABSTARCT

Solar energy is getting popular nowadays. Technologies have been developed which made solar energy a cheaper and reliable source of energy. Due to pollution and other factors, solar has become the most popular source of energy. Along with power generation, now water heaters are also developed which are working on the solar technology. It is a reliable method and can be used in areas which do not have access to wood, coal and gas. This project is based on design and fabrication of solar water heater. The main focus is given on increasing surface area exposed to sunlight. In this project, active water heaters are employed with pipes of circular and rectangular cross section. Local materials and manufacturing methods were used to fabricate the solar water heater to limit the cost of project. The result obtained was compared for both the configurations. The temperature rise was not remarkable as was expected. Two distinct problems were observed regarding this. One was the pipes were not run full of water; as a result heat on pipe surface couldn't transfer the heat properly to the flowing water. There was always a gap between the hot surface and top layer of water in the pipe. Secondly, the diameter/ width of pipes were large; as a result heat was transferred to the upper level of water only.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Introduction

This project is intended to design a water heating system by using solar technology. There are various design and manufacturing constraints but here the most general and efficient way would be used. It includes thorough study of the mechanism of the solar water heater. After designing such mechanism, the heater would be manufactured, and the results would be presented. Solar energy technology is used in various places in different ways. It is used to produce electricity and it provides energy which is used to cook food. [1] Solar systems are designed in such a way that water can be heated to any temperature. But at domestic levels water can be heated up to 60°C. Evacuate types of solar heaters and glazed plate heaters are the most common types of solar powered water heaters used in the world. Some of the systems are active and others are passive. Active systems are divided into direct and indirect solar systems. In this project indirect solar system will be designed.

The world relies heavily on fossil fuels for most of its energy demands, and this has caused a lot of harm to the Earth. [2] The increase of green-house gas levels in the atmosphere is largely due to the combustion of fossil fuels as a source of energy. This has caused global warming which has led to climate change, floods, forest fires, rising sea levels and the melting of glaciers. These are just some consequences of the over-reliance on fossil fuels for our energy demands. Solar energy provides an alternative and environmentally friendly energy source to the fossil fuels used for our energy needs. Over the last few decades, solar energy systems have gained more recognition because they can provide energy at a low long-term cost and minimal environmental damage.

[3] Researchers have developed several techniques for harnessing solar energy, these techniques include applications for space heating, water heating, electricity generation and many others. Solar energy is generated by the fusion reaction of hydrogen atoms in the sun. This fusion reaction results in the release of high-energy particles called gamma rays. Gamma rays are transmitted as electromagnetic radiation to the Earth, which is at

about 150 million kilometers from the sun. Electromagnetic radiation comes in three forms: infrared rays, visible light, and ultraviolet rays. [4] Solar energy reaching the Earth's surface can be harnessed directly by using photovoltaic (solar cells) and solar concentrators. Photovoltaic are used for electricity generation, while solar concentrators are used as a source of thermal energy. The utilization of solar energy collectors (concentrators) to transform radiation into heat energy is the basis of the solar water heating technology. A simple solar water heater consists of a collector, a tank, and the flow channel through which the working fluid is transported.

1.2 Problem Statement

Considering the epileptic nature of electric power supply in our country, the reliance on solar applications for water heating will lead to better reliability of service for hot water needs and will have minimal negative impact on the environment. This would reduce the reliance on electric heaters, which have higher operational costs and depend on fossil fuels as a primary energy source.

1.3 Motivation for the Study

A lot of research has gone into the solar energy field over the past few decades. This is mostly because of the increased world-wide acknowledgement of the environmental effects that the use of fossil fuel as an energy source comes with. This current study would result in the design and construction of a portable solar water heating system which would provide hot water. The use of locally sourced materials would reduce the financial resources required compared to the importation of these materials. With this system our country going through a recession and a pandemic which has further impacted the nation's economy, the availability of locally made solar water heating systems would help boost the local economy and curb the rate of importation.

1.4 Objective

The aim of this project is to design and construct a portable solar water heater. The objectives are:

- To fabricate solar water heaters with rectangular and circular cross section pipes.
- To increase the heat transfer to the pipe water using more exposed surface to the sun.
- To compare the performance (heat absorbed by water) for pipes of different configuration as stated above.

1.5 Structure of the Project

This Project is organized as follows:

Chapter 1 Introduction: The first chapter contains the statement of the introduction, problem statement, motivation of our study, objectives and the project outline.

Chapter 2 Literature Review: The chapter two contains introduction, about solar water heater theory, types of solar water heater, literature review part and summary.

Chapter 3 Hardware and Software Analysis: Chapter three describes the theoretical model. Here we mainly discuss about proposed system about Hardware.

Chapter 4 Methodology: Chapter four deals with our project methodology, working steps, block diagram, structural design, working principle.

Chapter 5 Result and Discussion: Chapter five details with our project discussion, result part of our project advantages and our project application study.

Chapter 6 Conclusion: Chapter six all about our project conclusion and future scope.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this section topics related to Fabrication and performance evaluation of rectangular and circular cross section solar water heaters System are included. These provide a sampling of problems appropriate for application of Fabrication and performance evaluation of rectangular and circular cross section solar water heaters. The references are summarized below.

2.2 What is Solar Water Heater

Solar water heater the conversion of sunlight into renewable energy for water heating using a solar thermal collector. Solar water heating system comprises various technologies that are used worldwide increasing. In a “close-coupled SWH system the Storage Tank is horizontally mounted immediately above the solar collectors on the roof. No pumping is required as the hot water naturally rises into the tank thought thermo siphon flow. [5] In a “pump-circulated” system the storage tank is ground – or floor – mounted and is below the level of the collectors; a circulating pump moves water or heat transfer fluid between the tank and the collector.

A Solar Water Heater is a device which provides hot water for bathing, washing, cleaning, etc. using solar energy. It is generally installed at the terrace or where sunlight is available and heats water during day time which is stored in an insulated storage tank for use when required including morning. We are blessed with Solar Energy in abundance at no cost. The solar radiation incident on the surface of the earth can be conveniently utilized for the benefit of human society. One of the popular devices that harness the solar energy is solar hot water system (SHWS). [6] A solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water. The solar energy incident on the absorber panel coated with selected coating transfers the hat to the riser pipes underneath the absorber panel. The water passing through the risers get heated up and are delivered the storage tank. The re-circulation of the same water through absorber panel in the collector raises the temperature to 80°C (Maximum) in a good sunny day [7].

The total system with solar collector, storage tank and pipelines is called solar hot water system. Broadly, the solar water heating systems are of two categories. They are: closed loop system and open loop system. In the first one, heat exchangers are installed to protect the system from hard water obtained from bore wells or from freezing temperatures in the cold regions.

2.3 Types of Solar Water Heaters

Solar water heaters can be either active or passive. An active system uses an electric pump to circulate the heat transfer fluid; a passive system has no pump. The amount of hot water a solar water heater produces depends on the type and size of the system, the amount of sun available at the site, proper installation, and the tilt angle and orientation of the collectors. Solar water heaters are also characterized as open loop (also called “direct”) or closed loop (also called “indirect”). An open-loop system circulates household (portable) water through the collector. A closed-loop system uses a heat-transfer fluid (water or diluted antifreeze, for example) to collect heat and a heat exchanger to transfer the heat to household water.

2.3.1 Active Systems

Active systems use electric pumps, valves, and controllers to circulate water or other heat-transfer fluids through the collectors. They are usually more expensive than passive systems but are also more efficient. Active systems are usually easier to retrofit than passive systems because their storage tanks do not need to be installed above or close to the collectors. But because they use electricity, they will not function in a power outage. Active systems range in price from about $2,000 to $4,000 installed.

2.3.2 Open-Loop Active Systems

Open-loop active systems use pumps to circulate household water through the collectors. This design is efficient and lowers operating costs but is not appropriate if your water is hard or acidic because scale and corrosion quickly disable the system. These open-loop systems are popular in nonfreezing climates such as Hawaii. They should never be installed in climates that experience freezing temperatures for sustained periods. You can install them in mild but occasionally freezing climates, but you must consider freeze protection. Recirculation systems are a specific type of open-loop system that provide freeze protection. They use the system pump to circulate warm water from storage tanks through collectors and exposed piping when temperatures approach freezing. Consider recirculation systems only where mild freezes occur once or twice a year at most. Activating the freeze protection more frequently wastes electricity and stored heat. Of course, when the power is out, the pump will not work and the system will freeze. To guard against this, a freeze valve can be installed to provide additional protection in the event the pump doesn’t operate. In freezing weather, the valve dribbles warmer water through the collector to prevent freezing.

2.3.3 Closed-Loop Active Systems

These systems pump heat-transfer fluids (usually a glycol-water antifreeze mixture) through collectors. Heat exchangers transfer the heat from the fluid to the household water stored in the tanks. Double-walled heat exchangers prevent contamination of household water. Some codes require double walls when the heat transfer fluid is anything other than household water.

2.3.4 Passive Systems

Passive systems move household water or a heat-transfer fluid through the system without pumps. Passive systems have no electric components to break. This makes them generally more reliable, easier to maintain, and possibly longer lasting than active systems. Passive systems can be less expensive than active systems, but they can also be less efficient. Installed costs for passive systems range from about $1,000 to $3,000, depending on whether it is a simple batch heater or a sophisticated thermo siphon system.

2.4 Literature Review

The solar energy that the Earth receives in a day is far greater than the total amount of energy that humans use up in the same time period. Eighteen days of the incident solar radiation on Earth would give an equivalent amount of energy when compared to all the planet's reserves of natural gas, coal and oil (Union of concerned scientists, 2015). Outside the earth’s atmosphere, solar radiation contains about 1,300 watts per square meter. [4] A third of this gets reflected into space once it reaches the earth’s atmosphere, the rest travels toward the surface of the earth. On average, over the earth's surface, every square meter receives about 4.2 kilowatt-hours of solar energy in a day (Union of concerned scientists, 2015).

Although the solar energy received by the Earth daily is greater than amount used by humans, the intensity of this solar energy or radiation incident on the Earth's surface depends on some factors. These factors include the geographic location and its inherent climate, the weather patterns or season and the time of day. [5] At certain periods within the year, the Earth is near the sun, this is because the Earth revolves elliptically around the sun. When the Earth is nearer the sun, its surface receives a higher amount of solar radiation. Earth's rotation around the sun is on a tilted axis of 23.5° and this plays a role in determining the incident radiation at a given location. For the six months within the two equinoxes, the Earth's tilted rotation brings about longer daytime in the northern hemisphere. [6] The southern hemisphere on the other hand, has longer days for the six months after the fall equinox. The southern parts of the United Kingdom and other middle latitudes get higher amounts of radiation during summer due to the longer days.

However, during winter, regions around the middle latitude receive lower amounts of solar energy because the solar rays are incident at a tilted angle during winter in middle latitude regions (Office of energy efficiency and renewable energy, 2013). The intensity of the solar radiation received on the earth's surface depends on the angle the sun's rays make with the earth's surface. This angle ranges from 0°: when the sun is just above the skyline, to 90°: when the sun is directly overhead. [7] The greatest intensity of solar radiation striking the Earth's surface can be observed at solar noon. This is when the sun is at its highest position (90°) in the sky, on a clear, cloudless day (Energy information administration, 2020). At angles less than 90°, the solar rays travel longer distances through the atmosphere, making them less intense by the time they reach the Earth's surface.

As solar rays travel through the Earth's atmosphere, some rays get absorbed or reflected and others get scattered. Various elements such as the air molecules, water vapor, the clouds, dust particles and volcanoes influence whether the solar rays get absorbed, reflected, or scattered. Based on this, solar radiation is classified into two components, diffuse and direct beam solar radiation. [8] Direct beam rays reach the earth's surface without being diffused. Diffuse rays get scattered, absorbed or reflected by the dust particles, air molecules or water vapour in the Earth's atmosphere (Adefarati & Bansal, 2019).

When the solar collector of a SWH is inclined, the diffuse rays striking it comprise the sky diffuse radiation, and a third component of solar radiation: Ground reflected radiation (Ineichen et al., 1990). The ground reflected radiation reflects off the earth surface and strikes the collector. [9] The direct radiation gets affected by atmospheric conditions, on a clear, dry day it can reduce by up to 10% and during thick, cloudy days, by up to 100% (Office of energy efficiency and renewable energy, 2013). Global solar radiation is the total amount of solar energy the earth's surface receives, it is equivalent to the sum of the diffuse, direct beam and ground reflected radiation.

While concentrating solar systems require direct beam solar radiation to function properly, the flat-plate collector system functions properly with both the diffuse and direct beam solar radiation (Energy information administration, 2020). Scientific researchers record the amount of solar radiation incident on specific locations at various periods during the year. [10] These values are used to estimate the amount of solar radiation incident in other locations with similar latitudes and local weather. Solar energy measurements are usually expressed as the total amount of solar radiation on a horizontal surface, or as the total solar radiation on a surface tracking the sun. Solar radiation data is usually represented as kilowatt-hours per square meter (Office of energy efficiency and renewable energy, 2013).

2.5 Summary

We try to do this project by reading the above literature, and we have been able to make our project successful by reducing the mistakes of last year's project.

CHAPTER 3

HARDWARE AND SOFTWARE ANALYSIS

3.1 Plastic Pipe

Plastic pipe is a tubular section, or hollow cylinder, made of plastic. It is usually, but not necessarily, of circular cross-section, used mainly to convey substances which can flow liquids and gases (fluids), slurries, powders and masses of small solids. It can also be used for structural applications; hollow pipes are far stiffer per unit weight than solid members.

Product Description:

Product Name:	clear pvc tubing
Material:	pvc
Size:	from 1/8inch (ID 3mm) to 2inch (ID 50mm)
Wall Thickness:	from 1mm to 4mm
Color:	clear / blue / red / yellow / black / green / orange etc.
Working Pressure:	from 2bar (30psi) to 4bar (60psi)
Temperature Range:	from -5 to 65 degree C.
Length/roll	10m, 20m, 30m, 50m/roll or other.

Application:

Suitable for low pressure transfer of various Fluids and air, such as fuel, water, light chemicals, oxygen, gas for watering systems, peristaltic pumps, electrical and thermal insulation, analytical systems in plant equipment, laboratories, watering system and many other low pressure industry applications.

Figure 3.1 : Plastic Pipe

3.2Temperature Meter

A temperature meter is an instrument used to measure the temperature of beings or things. The most widely recognized temperature meter is a mercury thermometer used to measure the temperature of people.

Figure 3.2: Temperature Meter

Specification

- Temperature range: -50~ +110°C
- Using environment: Temperature: -5~ +50°C Humidity: 5%~80%
- Accuracy: ±1°C
- Size: 47*28*14mm
- Weight: 22g
- Color: Black and white

3.3 Pump Motor

Figure 3.3: Pump Motor

- Power:16.8W
- Max Flow Rate: 700 L/H
- Max Water Head: 5M Max
- Circulating Water Temperature: 60°C

Specification:

- Material: ABS (Acrylonitrile Butadiene Styrene) + Stainless Steel
- Overall Size: Approx. 80 x 48 x 63mm/3.15 x 1.89 x 2.48"
- Pump Inlet Diameter: 16mm (Outer), 12mm (Inner)
- Pump Outlet Diameter: 12mm (Outer), 6.9mm (Inner)
- Inlet/Outlet: 1/2" male thread
- Voltage: 6-12V DC
- Maximum Rated Current: 1.2A
- Power: 16.8W
- Max Flow Rate: 700 L/H
- Max Water Head: 5M
- Max Circulating Water Temperature: 60°C

3.4 Rectangular Pipe

A **structure** is an arrangement and organization of interrelated elements in a material object or system, or the object or system so organized.[1] Material structures include man-made objects such as buildings and machines and natural objects such as biological organisms, minerals and chemicals. Abstract structures include data structures in computer science and musical form. Types of structure include a hierarchy (a cascade of one-to-many relationships), a network featuring many-to-many links, or a lattice featuring connections between components that are neighbors in space Buildings, aircraft, skeletons, anthills, beaver dams, bridges and salt domes are all examples of load-bearing structures. The results of construction are divided

Figure 3.4: Rectangular Pipe

into buildings and non-building structures, and make up the infrastructure of a human society. Built structures are broadly divided by their varying design approaches and standards, into categories including building structures, architectural structures, civil engineering structures and mechanical structures. The effects of loads on physical structures are determined through structural analysis, which is one of the tasks of structural engineering. The structural elements can be classified as one-dimensional (ropes, struts, beams, arches), two-dimensional (membranes, plates, slab, shells, vaults), or three-dimensional (solid masses).[2]: 2 Three-dimensional elements were the main option available to early structures such as Chichen Itza. A one-dimensional element has one dimension much larger than the other two, so the other dimensions can be neglected in calculations; however, the ratio of the smaller dimensions and the composition can determine the flexural and compressive stiffness of the element. Two-dimensional elements with a thin third dimension have little of either but can resist biaxial traction.[2]: 2–3

3.5 Circular Pipe

The structure elements are combined in structural systems. The majority of everyday load-bearing structures are *section-active* structures like frames, which are primarily composed of one-dimensional (bending) structures. Other types are *Vector-active* structures such as trusses, surface-active structures such as shells and folded plates, *form-active* structures such as cable or membrane structures, and hybrid structures.[3]: 134–136 Load-bearing biological structures such as bones, teeth, shells, and tendons derive their strength from a multilevel hierarchy of structures employing bio minerals and proteins, at the bottom of which are collagen fibrils. In biology, one of the properties of life is its highly ordered structure,[5] which can be observed at multiple levels such as in cells, tissues, organs, and organisms.

Figure 3.5: Circular Pipe

In another context, structure can also observe in macromolecules, particularly proteins and nucleic acids.[6] The function of these molecules is determined by their shape as well as their composition, and their structure has multiple levels. Protein structure has a four-level hierarchy. The *primary structure* is the sequence of amino acids that make it up. It has a peptide backbone made up of a repeated sequence of a nitrogen and two carbon atoms. The *secondary structure* consists of repeated patterns determined by hydrogen bonding. The two basic types are the α-helix and the β-pleated sheet. The *tertiary structure* is a back and forth bending of the polypeptide chain, and the *quaternary structure* is the way that tertiary units come together and interact.[7] Structural biology is concerned with bimolecular structure of macromolecules

Chemical structure refers to both molecular geometry and electronic structure. The structure can be represented by a variety of diagrams called structural formulas. Lewis structures use a dot notation to represent the valence electrons for an atom; these are the electrons that determine the role of the atom in chemical reactions.[8]: 71–72 Bonds between atoms can be represented by lines with one line for each pair of electrons that is shared. In a simplified version of such a diagram, called a skeletal formula, only carbon-carbon bonds and functional groups are shown.

A **pipe** is a tubular section or hollow cylinder, usually but not necessarily of circular cross-section, used mainly to convey substances which can flow — liquids and gases (fluids), slurries, powders and masses of small solids. It can also be used for structural applications; hollow pipe is far stiffer per unit weight than solid members.
In common usage the words *pipe* and *tube* are usually interchangeable, but in industry and engineering, the terms are uniquely defined. Depending on the applicable standard to which it is manufactured, pipe is generally specified by a nominal diameter with a constant outside diameter (OD) and a schedule that defines the thickness. Tube is most often specified by the OD and wall thickness, but may be specified by any two of OD, inside diameter (ID), and wall thickness. Pipe is generally manufactured to one of several international and national industrial standards.[1] While similar standards exist for specific industry application tubing, tube is often made to custom sizes and a broader range of diameters and tolerances. Many industrial and government standards exist for the production of pipe and tubing.

The term "tube" is also commonly applied to non-cylindrical sections, i.e., square or rectangular tubing. In general, "pipe" is the more common term in most of the world, whereas "tube" is more widely used in the United States. Both "pipe" and "tube" imply a level of rigidity and permanence, whereas a *hose* (or hosepipe) is usually portable and flexible. Pipe assemblies are almost always constructed with the use of fittings such as elbows, tees, and so on, while tube may be formed or bent into custom configurations. For materials that are inflexible, cannot be formed, or where construction is governed by codes or standards, tube assemblies are also constructed with the use of tube fittings.

CHAPTER 4

METHODOLOGY

4.1 Our methodologies for the project

Our methodologies for the project:

- Creating an idea for design and construction of a **Pipe Solar Water Heater**. And designing a block diagram &structural diagram to know which components we need to construct it.
- Collecting all the components of our system.
- Setting up all the components in a PCB board & then soldering. Lastly, assembling all the blocks in a board and to run the system & for checking purposes.

4.2 Working Step Chart

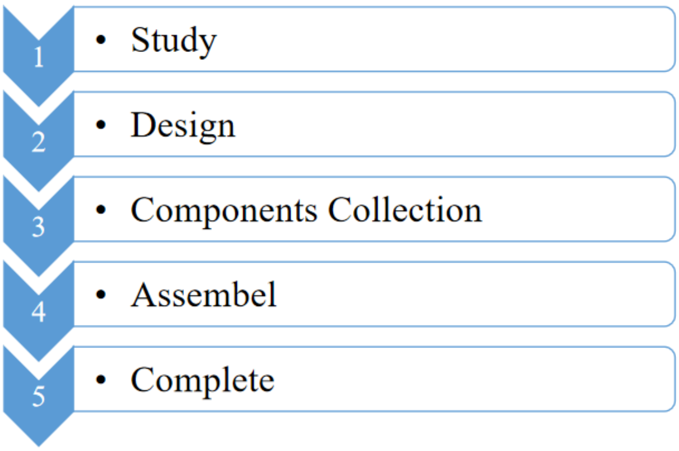

Figure 4.1: Working Step Chart

4.3 Block Diagram

The way of whole project works is that we take 220V AC power from the supply voltage and then feed it to a Switch Mode Power Supply or in short SMPS module. The SMPS simply converts the 220V AC to a pure DC of 5V 5Amp. We will use this 5V DC output from the SMPS to run our controller, motor and other units.

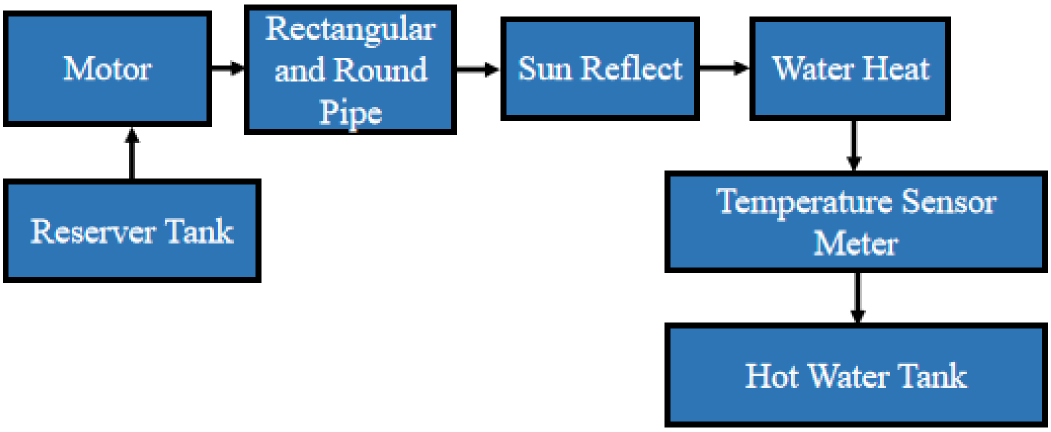

Figure 4.2: Block Diagram of Our System

4.4 Structural Design

The schematic diagram here is representing the electrical circuit and the components of the project. Here we have used standardized symbols and lines.

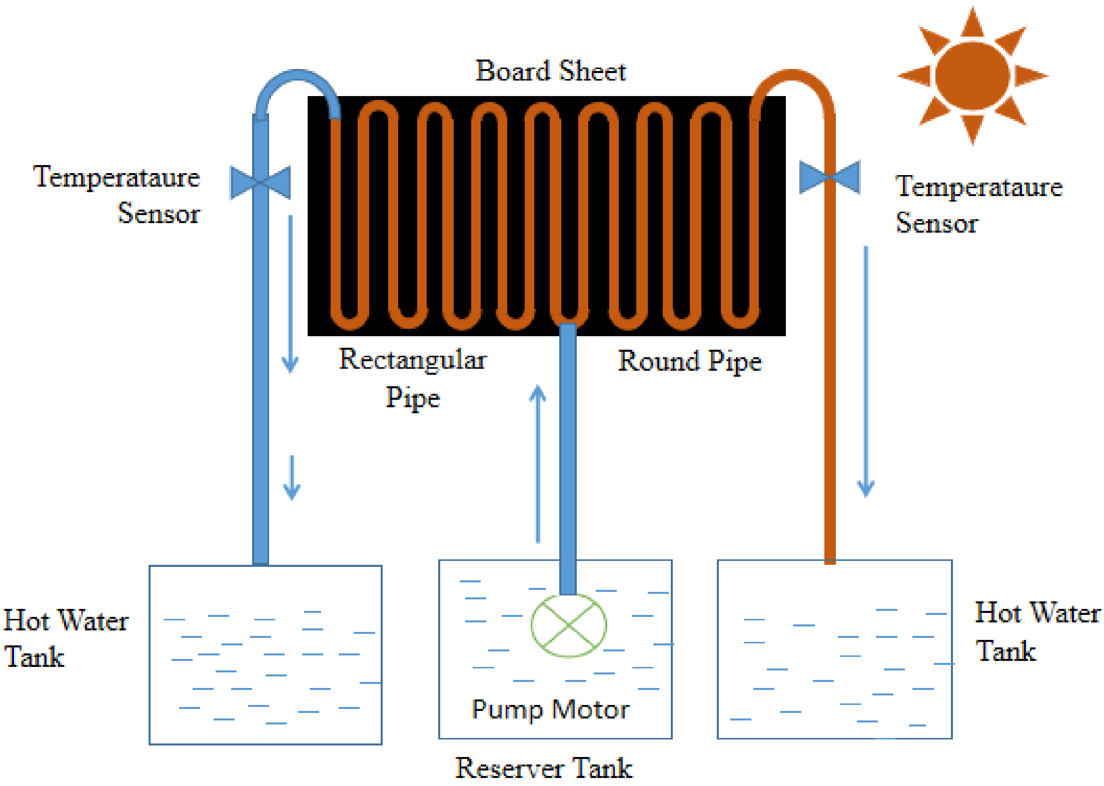

Figure 4.3: Structural Diagram of the Project

4.5 Working Principle

Our main power supply for this system is AC 220 voltage. This power is connected to the SMPS. The main function of SMPS is to convert AC to DC. Since all our instruments in this project are DC, we need DC power. This SMPS will be supply fixed 5V DC, 5Amp in this system. Here we use Pump motor, Round Pipe, Reserve tank, hot water tank etc. In this system we will heat water mainly by using solar energy. Here we use pump motor, Round Pipe, Temperature Sensor meter, Reserve tank etc. Water will enter from the reserve time by pressing the toward through the pump and there the temperature of the water will be measured with a temperature sensor. Reserve tank water is normal. After reach the MS Round Pipe water will be heated and goes heated water tank and store it for future uses. MS Round Pipe will absorb heat from sun. This is the main purpose of this system.

4.6 Final System View

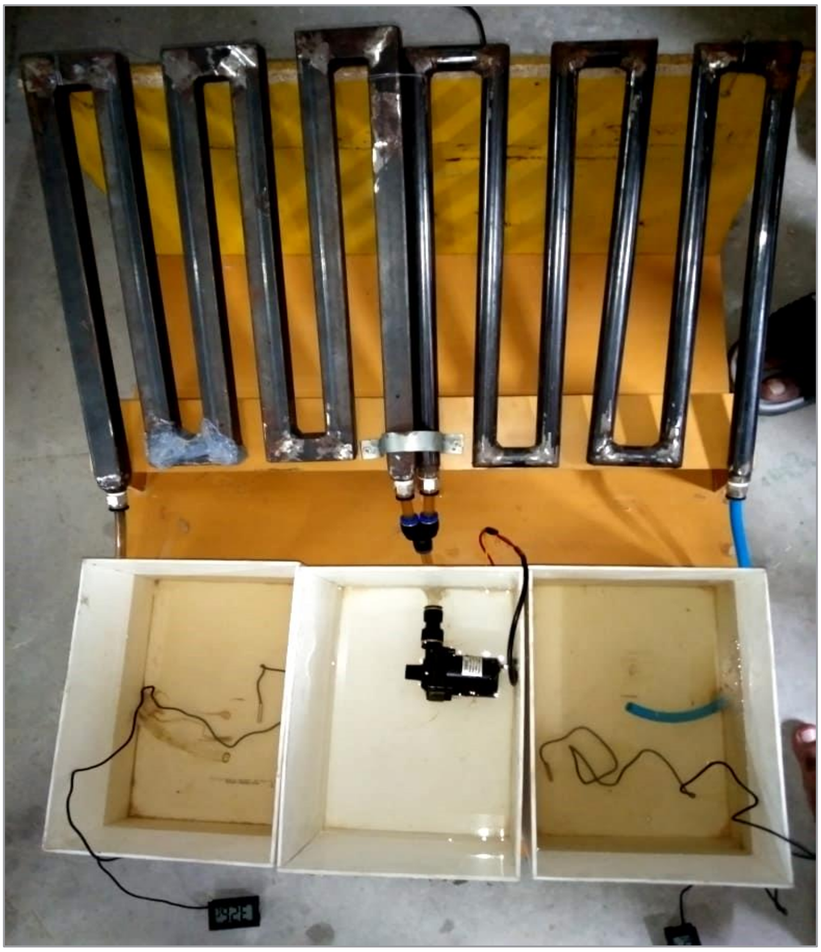

Figure 4.4: Final System Overview (Top View)

CHAPTER 5

RESULT AND DISCUSSION

5.1Discussion

If we reduce the distance out of the rectangular then the water will flow through the entire length of the pipe. A circular pipe accepts heat from the sun than a square pipe. As a result, the water in the circular pipe becomes hotter. In this we can measure the correct temperature. While working on our project, we did face some difficulties as it is a very complex system but the end results, we came up with were quite satisfactory. We have put the whole system through several tasks to validate our work and also have taken necessary notes for future improvements. Some future recommendations that we have involves improvement in system design and wiring, adding features for more efficient.

5.2 Data Table and Graph

Table no : 1 Rectangular pipe		
Time	Temperature in °c (Cold water)	Temperature out °c (Hot water)
10.00 am	28.1	31.3
10.30 am	28.9	32.1
11.00 am	29.8	33.4
11.30 am	30.3	34.9
12.00 pm	31	36

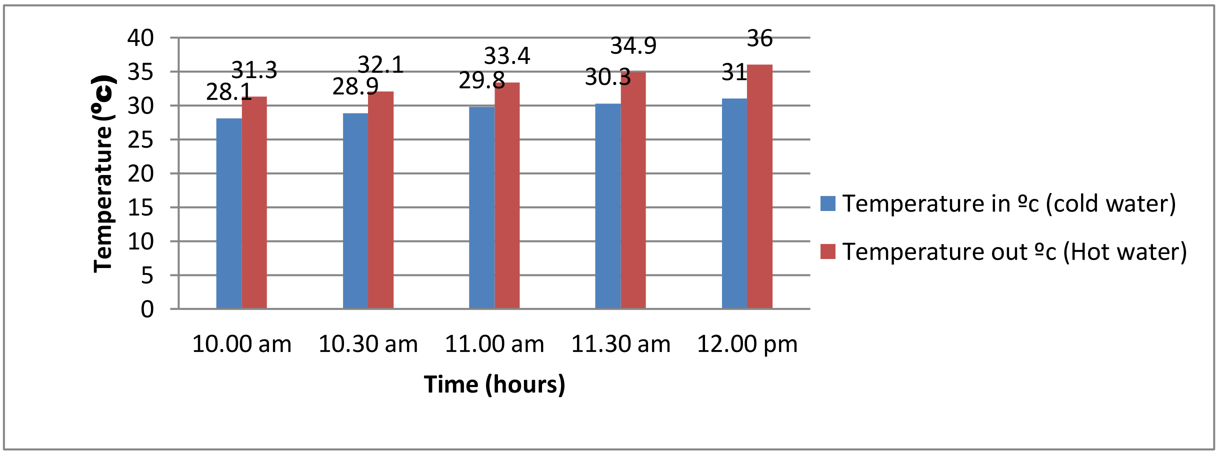

Figure 5.1: Cold and Hot Water Temperature Graph of Rectangular Pipe

Table no : 2 Circular pipe		
Time	Temperature in °c (Cold water)	Temperature out °c (Hot water)
10.00 am	28.1	32.1
10.30 am	28.9	33
11.00 am	29.8	34.8
11.30 am	30.3	35.8
12.00 pm	31	37.2

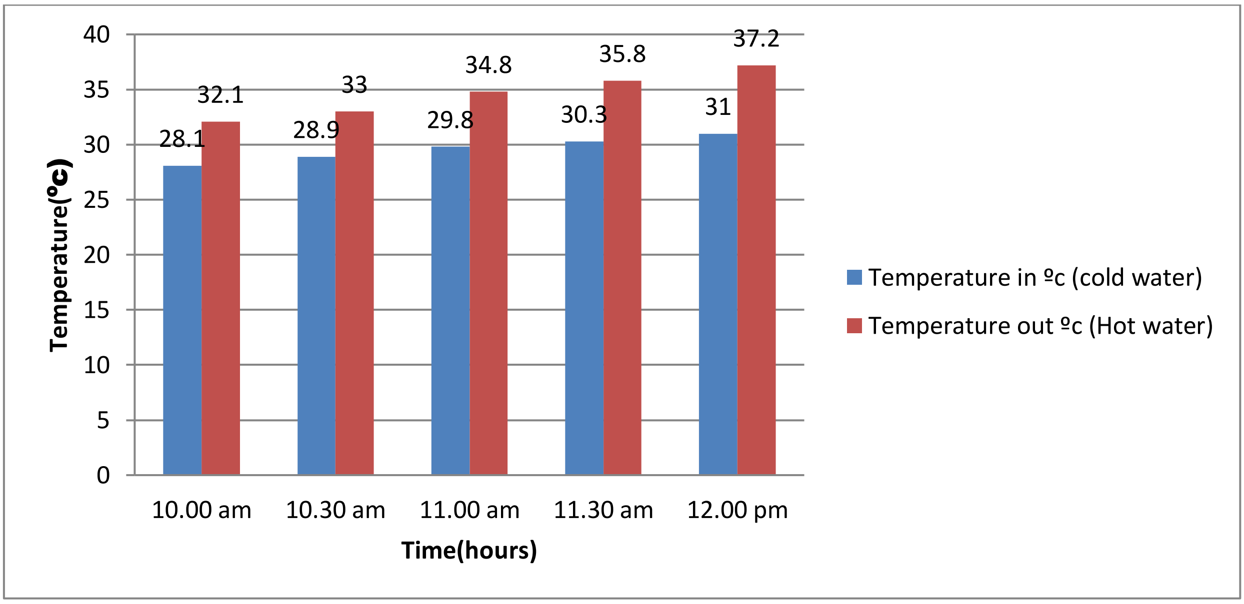

Figure 5.2: Cold and Hot Water Temperature Graph of Circular Pipe

Table no : 3 Rectangular pipe		
Time	Temperature in °c (Cold water)	Temperature out °c (Hot water)
2.10 pm	31.2	38.2
2.25 pm	31.6	34.2
2.40 pm	31.1	34
2.55 pm	31	32.2
3.10 pm	30.8	35.5

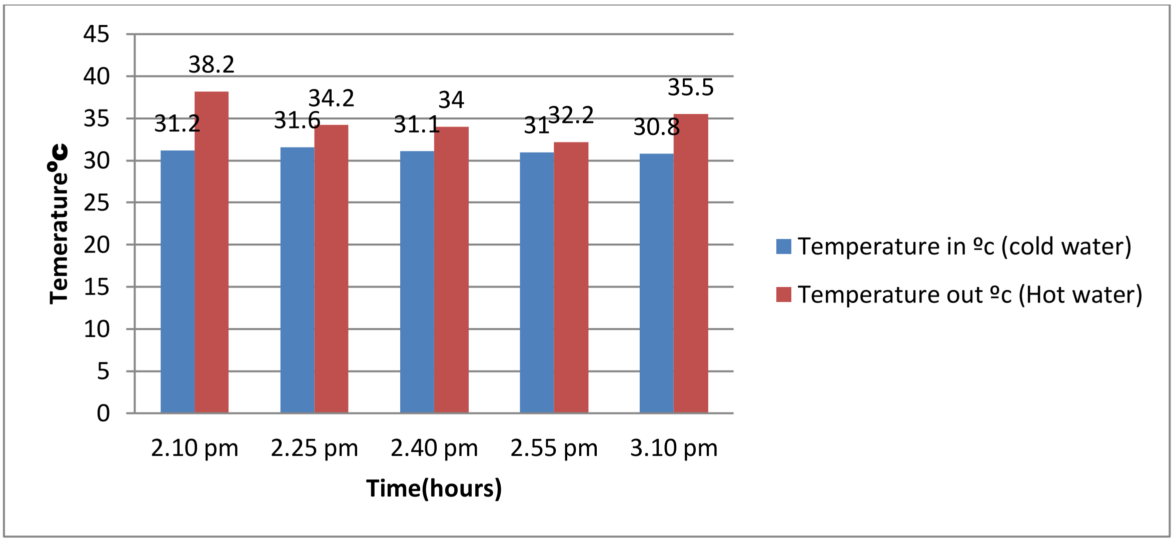

Figure 5.3: Cold and Hot Water Temperature Graph of Rectangular Pipe

Table no : 4 Circular pipe		
Time	Temperature in °c (Cold water)	Temperature out °c (Hot water)
2.10pm	31.2	39.8
2.25 pm	31.6	36.9
2.40 pm	31.1	33.7
2.55 pm	31	34.2
3.10 pm	30.8	36.3

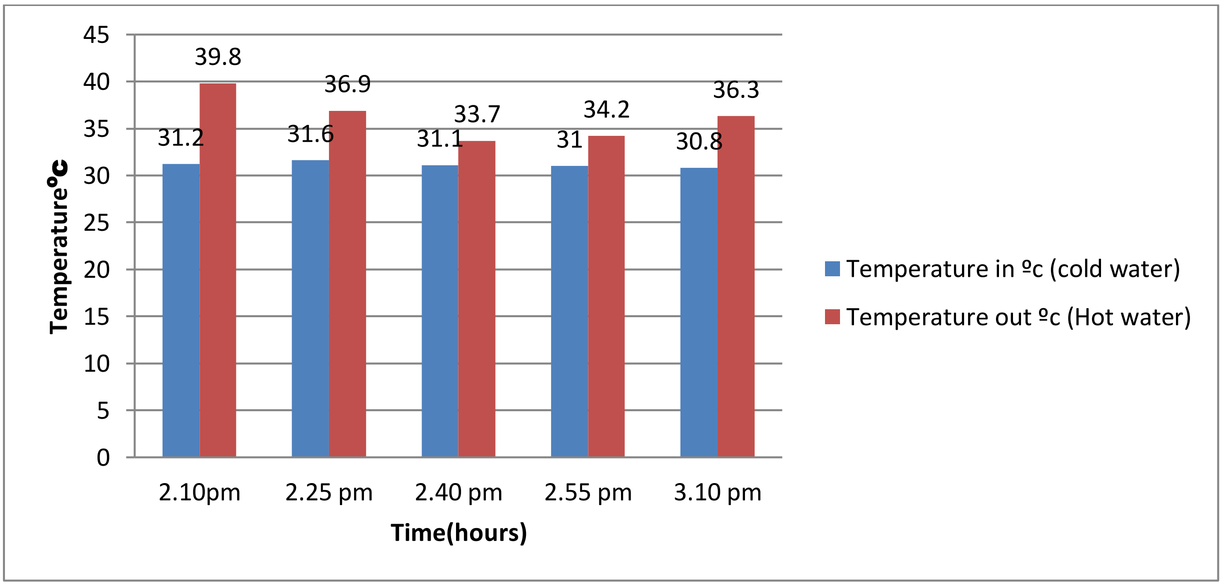

Figure 5.4: Cold and Hot Water Temperature Graph of Circular Pipe

Table no : 5 Rectangular pipe			
Time	Temperature in °c (Cold water)	Temperature out °c (Hot water)	Temperature Difference
10.00 am	28.1	31.3	3.2
10.30 am	28.9	32.1	3.2
11.00 am	29.8	33.4	3.6
11.30 am	30.3	34.9	4.6
12.00 pm	31	36	5

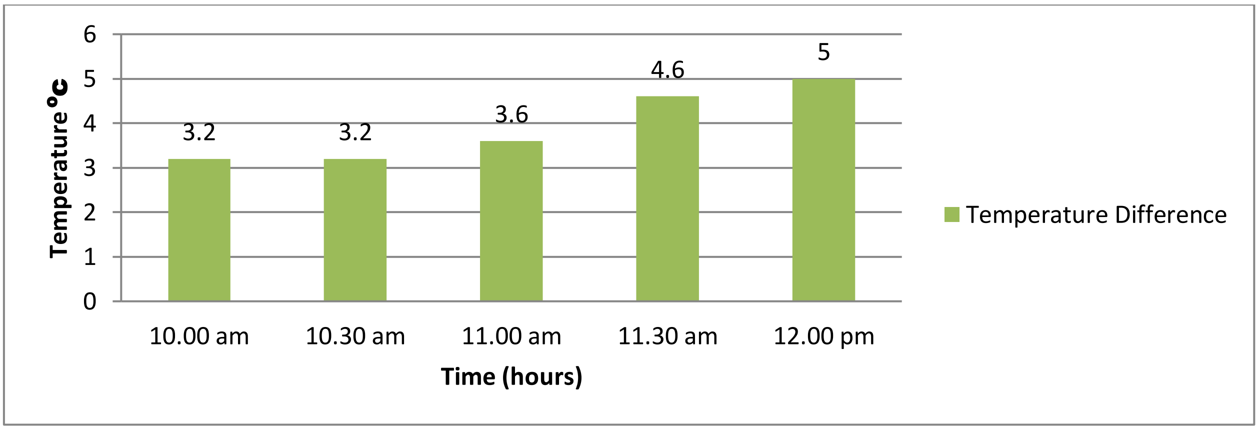

Figure 5.5: Cold and Hot Water Temperature Difference Graph of Rectangular Pipe

Table no : 6 Circular pipe			
Time	Temperature in °c (Cold water)	Temperature out °c (Hot water)	Temperature Difference
10.00 am	28.1	32.1	4
10.30 am	28.9	33	4.1
11.00 am	29.8	34.8	5
11.30 am	30.3	35.8	5.5
12.00 pm	31	37.2	6.2

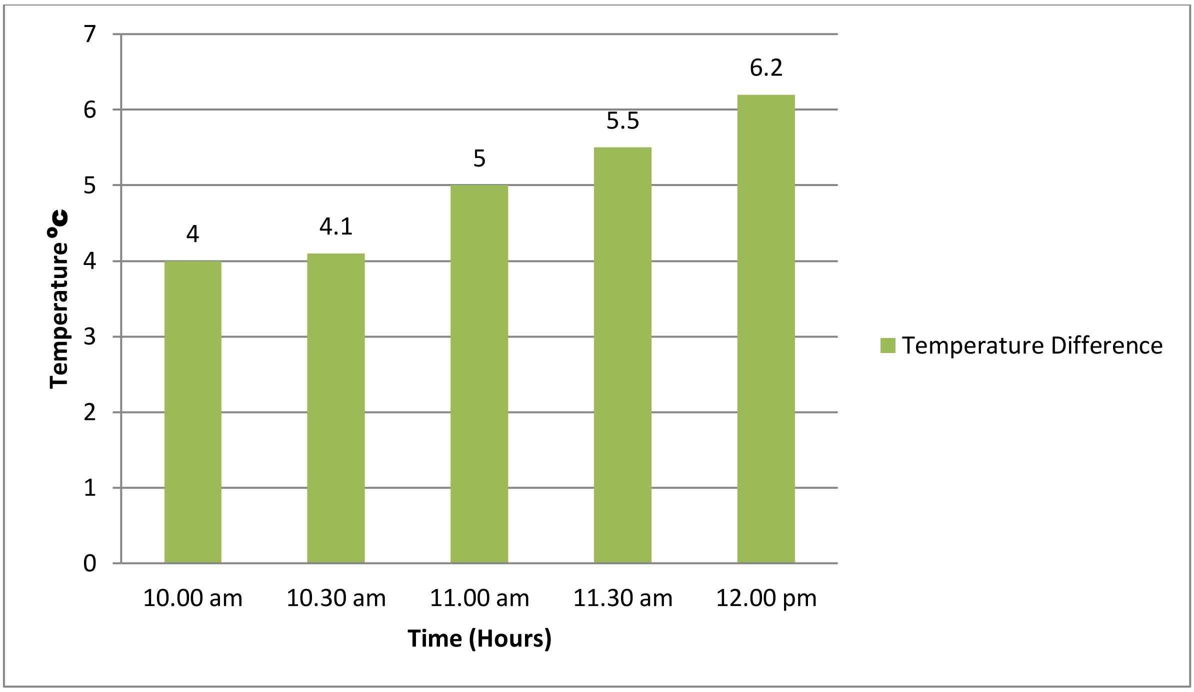

Figure 5.6: Cold and Hot Water Temperature Difference Graph of Circular Pipe

Table no : 7 Rectangular pipe			
Time	Temperature in °c (Cold Water)	Temperature out °c (Hot water)	Temperature Difference
2.10 pm	31.2	38.2	7
2.25 pm	31.6	34.2	2.6
2.40 pm	31.1	34	2.9
2.55 pm	31	32.2	1.2
3.10 pm	30.8	35.5	4.7

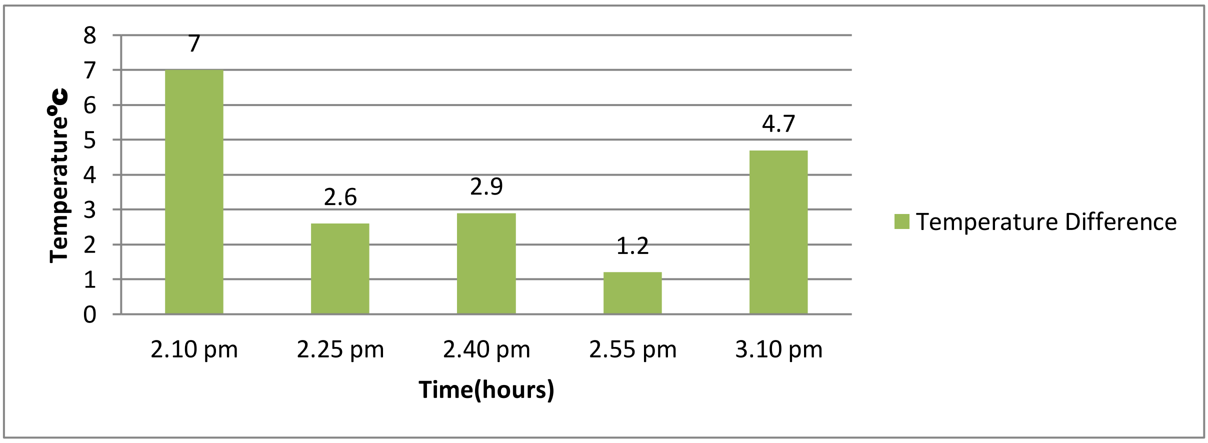

Figure 5.7: Cold and Hot Water Temperature Difference Graph of Rectangular Pipe

Table no : 8 Circular pipe			
Time	Temperature in °c (Cold Water)	Temperature out °c (Hot water)	Temperature Difference
2.10pm	31.2	39.8	8.6
2.25 pm	31.6	36.9	5.3
2.40 pm	31.1	33.7	2.6
2.55 pm	31	34.2	3.2
3.10 pm	30.8	36.3	5.5

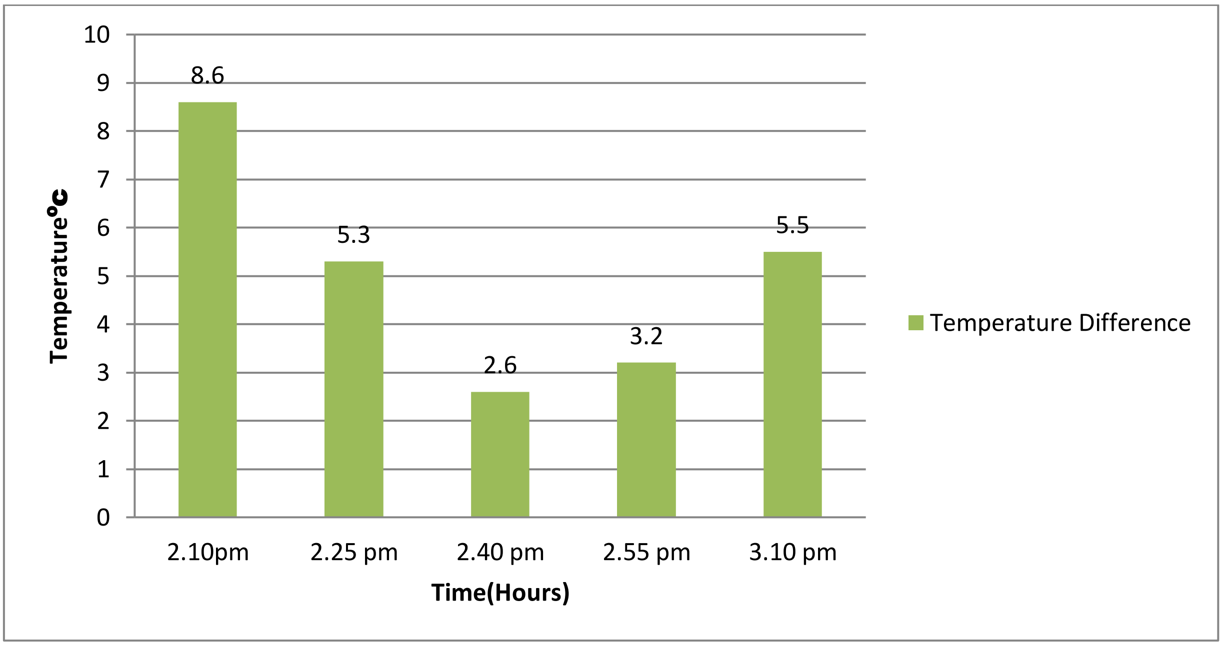

Figure 5.8: Cold and Hot Water Temperature Difference Graph of Circular Pipe

5.3 Calculation

V = Volume of the water tank (m^3)

T_i = Temperature of water at inlet (K)

T_o=Temperature of water at outlet (K)

L = Length (cm)

S = Edge (cm)

h = Height (cm)

A_r= Collector area (m^2)

A_c= Collector area (m^2)

I = Irradiance (w/m^2)

C_p =Specific heat of water (J/kg k)

m = Mass flow rate of water per second (kg/s)

Q_u= The rate of useful energy extracted by the collector

<u>Rectangular pipe:</u>

L= 127 cm

S= 2.54 cm

A_r=0.00322 m^2

m= 0.166 kg/s

C_p=4181j/kg.k

I= 1380w/m^2

Collector efficiency, η = $\frac{m*C_p*(T_o-T_i)}{A_r I}$

$$=\frac{0.166*4181(304.3-301.1)}{0.00322*1380}$$

=0.499

=49%

<u>Circular pipe:</u>

L= 127 cm

D= 1.905 cm

A_c=0.07606 m^2

m= 0.166 kg/s

C_p=4181 j/kg.k

I= 1380 w/m^2

Collector efficiency, η = $\frac{m*C_p*(T_o - T_i)}{A_r I}$

$=\frac{0.166*4181(307.1-302.8)}{0.00322*1380}$

=0.5246

=52%

5.4 Advantage

Using solar energy, rather than other sources of energies like fossil fuels and gasses helps us to reduce our dependence on the harmful energy resources. Therefore, solar water, heaters are 50% more efficient than other water heating system. They reduce greenhouse gases, improve the quality of the environment, and save our money. Cost of solar water, heating systems are usually expensive compare to other water heaters but it saves the users money in the long run. Its hot water will be essentially free after a few years (4-6 years) usage.

Some of the advantages are pointed out below:

1. Solar water heating is free process.
2. Water heating with a solar is healthy
3. Solar cookers make no noise.
4. Solar water heating system is portable.
5. Power cuts is not an issue
6. Cost-effectiveness
7. Reduce energy waste
8. No Oil consumption.
9. Simple construction
10. Ease of operation.

5.5 Disadvantages

1. Water will be heat slowly.
2. Foggy Weather it will not able to produce heat.
3. It is a demo project so it is use in small scale.

5.6 Application

Some of the application areas of the project have been pointed out below:

1. It can be used for Water heating
2. Heating water for commercial purposes.
3. Water Purification

CHAPTER 6
CONCLUSION

6.1 Conclusion

It was a demo project and intended to design and fabricate a solar water heater. This project was completed by following the research and theoretical knowledge. A reliable and low-cost solar water heater according to the local needs was developed as stated in the objectives. It involved a great research knowledge while designing the components and management skills. All the parts were manufactured and assembled to achieve the desired results by using the local materials and technologies. As stated earlier that project was designed and completed with local needs, it helps a lot to reduce the cost of project. It reduces the time and cost of the materials and manufacturing. It was a good project which involved five people. It was a great privilege for us to work in this project and complete it within time. Cost effectiveness was the main objective which was fulfilled throughout the project. We learn to work more in less time.

6.2 Future Scope

We expected to get a better heat transfer from our set up because of the extended heat transfer area. But unfortunately we didn't get that. The reasons were discussed in the result. To overcome these we recommend the followings:

a) Use of a header container to store the hot water from pipes so that the pipes run full.
b) Use pipes of smaller width having a larger surface area to overcome the difficulties of transfer of top heat to depth of pipe carrying water (as it will be having very small depth).

REFERENCE

[1] Abdunnabi, M., Rohuma, I., Endya, E., & Belal, E. (2018). Review on solar water heating in Libya.

[2] Adefarati, T., & Bansal, R. C. (2019). Energizing Renewable Energy Systems and Distribution Generation. In Pathways to a Smarter Power System (pp. 29–65). Elsevier.

[3] Alternative Energy Tutorials. (2015). Solar Flat Plate Collectors for Solar Hot Water.

[4] API Energy. (n.d.). Active Vented System. Retrieved September 29, 2020

[5] Atia, D. M., Fahmy, F. H., Ahmed, N. M., & Dorrah, H. T. (2012). Optimal sizing of a solar water heating system based on a genetic algorithm for an aquaculture system. Mathematical and Computer Modelling, 55(3–4), 1436–1449.

[6] Azom. (2005). Aluminium - Specifications , Properties , Classifications and Classes.

[7] Barry, C. (2018). thermal properties of glass fiber thread. B&W FIBERGLASS NEWS, 1.

[8] Dean, J. (n.d.). Domestic Hot Water Assessment Guidelines (Fact Sheet), Saving Energy In Commercial Buildings, NREL (National Renewable Energy Laboratory). Retrieved May 19, 2020,

[9] Eagle Stainless. (n.d.). Characteristics of Stainless Steel. Retrieved September 27, 2020

[10] Ekpo, J., & Enyinna, P. (2017). Design and Construction of a Solar Water Heater for Environmental Sustainability. British Journal of Applied Science & Technology, 20(3), 1–15.

[11] Harrison J, Tiedeman T (1997). “Solar Water Heating Options in Florida”, Florida Solar Energy Centre. Rpt: FSEC-EN-9-85.

[12] Soteris A. Kalogirou (2004). “Solar thermal collectors and applications.”, Progress in Energy and Combustion Science 30, pp 231–295.

[13] K. Sivakumar, N. Krishna Mohan and B. Sivaraman (2005) “Performance analysis of elliptical heat pipe solar collector” Indian Journal of Science and Technology

[14] Al-Madani, Hussain (2006). “The performance of a cylindrical solar water heater.” Renewable Energy Vol. 31, pp 1751-1763

[15] K. S. Ong, W. L. Tong, Sheriwati, K. Low (2011). “System Performance of Heat Pipe Solar Water Heaters” 10th IHPS, Taipei, Taiwan, pp 261-266.